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THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

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PATRON—HIS MAJESTY THE KING.

NOTES ON THE BREEDING HABITS AND EARLY STAGES OF SOME MUSCIDS ASSOCIATED WITH CATTLE IN ASSAM.

By R. C. Muirhead Thomson, D.Sc., F.R.E.S.

The observations in this paper were made at odd intervals between 1938 and 1941 while I was working on *Anopheles* in Assam. Time did not permit of any of these Muscids being studied in such detail as I would have liked ; but so much of the material is new that, incomplete as it is, it is worth putting on record.

In the absence of any means of identifying species accurately on the spot, some of them had to be given provisional names, corresponding roughly to those of Muscids found on cow dung in Europe. As the number of species was limited, and most had distinctive appearance and habits, there seemed little chance of species being confused. The material was identified by Dr. F. van Emden at the British Museum (Natural History), and I am very grateful to him for his assistance in this essential matter, and for pointing out to me some errors resulting from provisional field identification. For example, specimens of a "viviparous *Musca*," which had distinctive habits and uniform appearance in the field, proved to be made up of two species, *Musca bezzii* Patton and Cragg, and *M. illingworthi* Patton ; as will be described later, it appears that these two species must have identical habits. Another curious error was the division of a common Muscid into two groups in the field, provisionally called *Philaematomyia* A and B, which differed distinctly in size and appearance. Both groups were later found to belong to one species, *Musca crassirostris* Stein.

The Muscids associated with cattle and cow dung in Assam valley are as follows :

On shoulder sore of cattle :

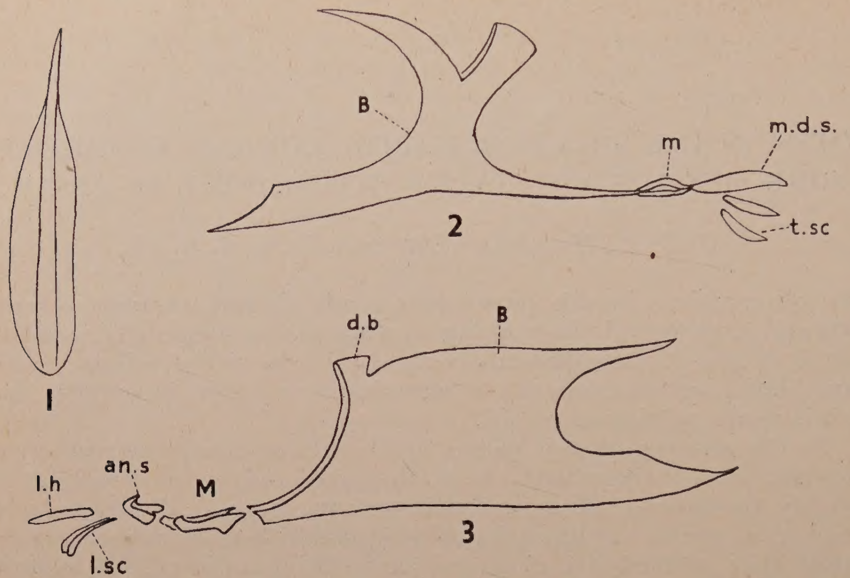
- *Musca crassirostris* Stein.
- *M. ventrosa* Wiedemann.
- *M. craggii* Patton.
- *M. conducens* Walker.
- *M. pattoni* Austen.

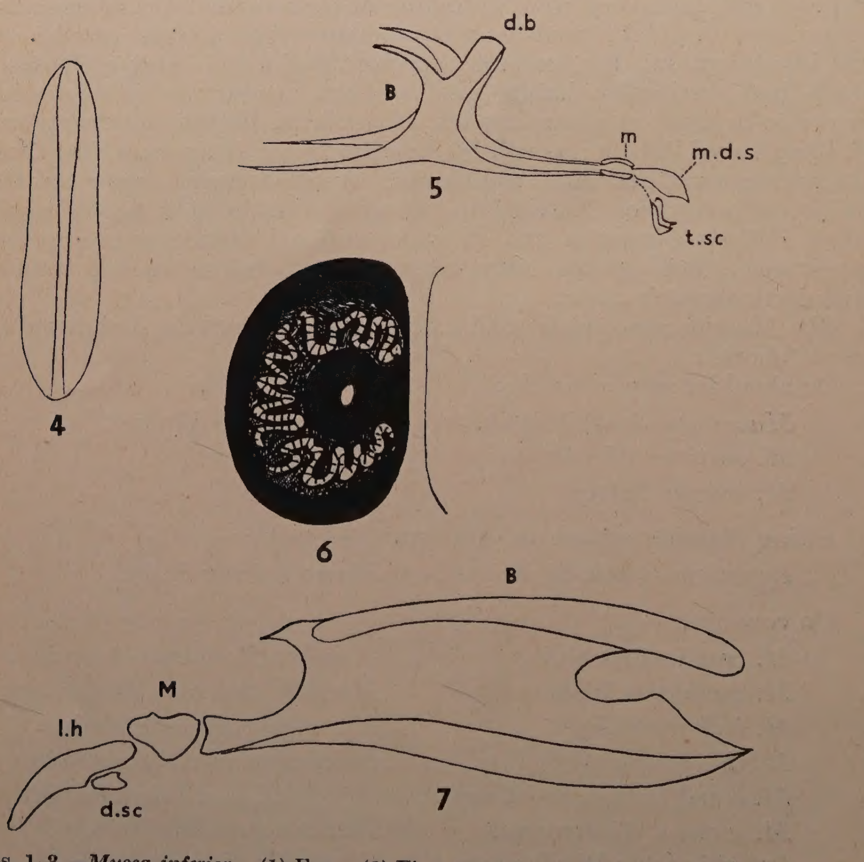
Biting Muscids settled on other parts of cattle :

- *Lyperosia exigua* de Meijere.
- *Musca inferior* Stein.

On cow dung :

- *M. crassirostris* Stein.
- *M. conducens* Walker.
- *M. inferior* Stein.
- *M. illingworthi* Patton.
- *M. bezzii* Patton and Cragg.
- *M. sorbens* Wiedemann.
- *Orthellia lauta* Wiedemann.
- *O. indica* Robineau-Desvoidy.
- *Morellia hortensia* Wiedemann.
- *Lyperosia exigua* de Meijere.
- *Hebecnema nigrithorax* Stein.
- *Anaclyste flexa* Wiedemann.
- *Xenosia ungulata* Stein.
- *Gymnodia distincta* Stein.





Figs. 1–3.—*Musca inferior.* (1) Egg. (2) First stage larva. Skeleton. (3) Second stage larva. Skeleton.

Figs. 4–7.—*Orthellia.* (4) Egg. (5) First stage larva. Skeleton. (6) Third stage larva. Posterior spiracles. (7) Third stage larva. Skeleton.

To save unnecessary repetition the descriptions of the larvàe have been limited as far as possible to important features, and continual reference has been made to a previous work of the author's (Muirhead Thomson, 1937) in which the saprophagous and carnivorous larvae of many species of European dung-frequenting Muscids, closely allied to the Assam species, have been described in some detail.

Musca inferior Stein.

The appearance of this Muscid on cattle is rather erratic in Assam. Sometimes not a single specimen can be seen, while on other occasions it is the dominant fly. Unlike *M. crassirostris*, it is not usually seen on shoulder sores of cattle, but may be common on the sides and underpart of the cow's body. Many of the flies, both male and female, burrow deeply into the cow's hair, and sometimes close bunches of two or three flies can be seen feeding together in this way.

Patton and Cragg (1913) considered that this was a hill species, and rare at that. They were unable to find out about its breeding habits, but showed by dissection that it was oviparous. Later (Patton and Senior White, 1924) it was recorded as having been bred from patches of cow dung. Recently Siddons and Roy (1940) have bred it from cow dung in the laboratory.

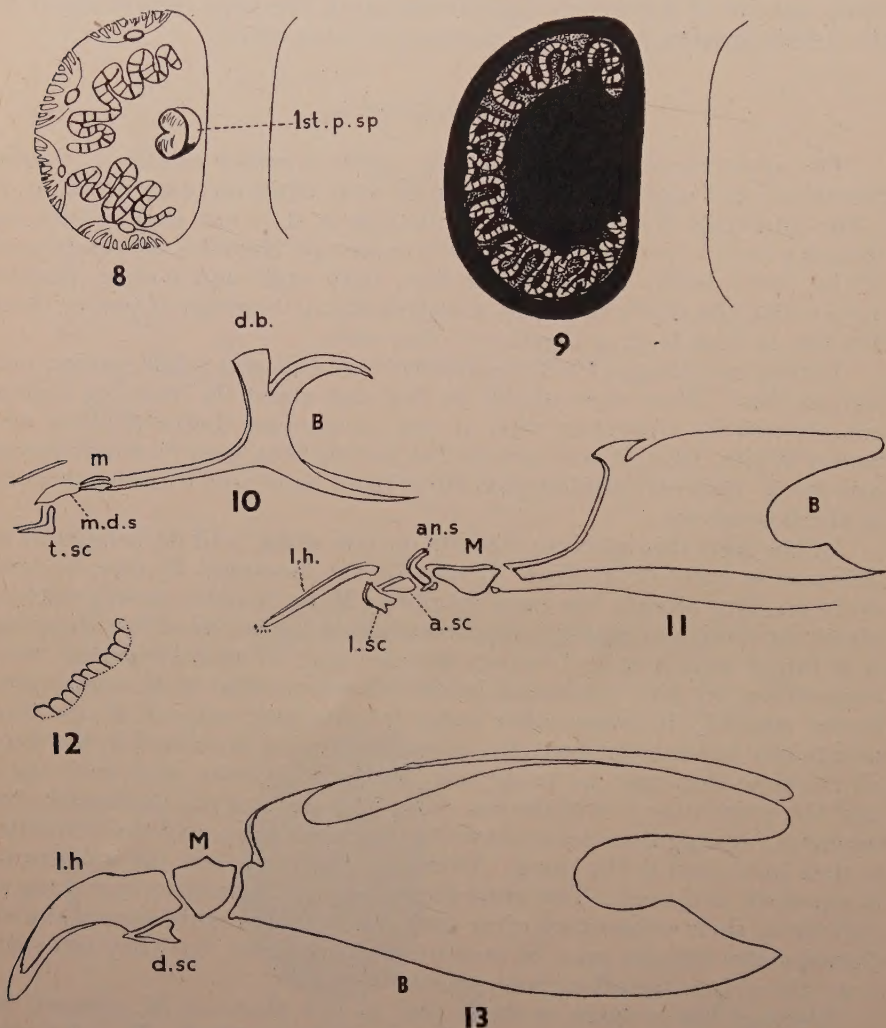
In the field this species oviposits on cow dung, and its behaviour at this time is quite distinctive. It may be the dominant fly on cow dung up to an hour after it has been dropped. Many females crawl excitedly about the dung, and finally concentrate about the centre of the dropping. A group of anything up to seven females may all crowd together when ovipositing, but this communal habit differs from that of *M. crassirostris* in one respect. In *crassirostris* many females may oviposit at one time practically in the same hole, the ovipositors being immersed in the dung all the time that eggs are being laid. With *M. inferior*, after each egg is laid the ovipositor is withdrawn, extended, and curved backwards and upwards. An egg then passes down to the extreme tip, and the ovipositor is then immersed in the dung. After the next egg is laid the withdrawal is repeated, and so on. This close group of large Muscids on cow dung all extending their ovipositors after each egg is laid is quite unmistakable. Occasionally females may be seen ovipositing alone, but they too withdraw the ovipositor after each egg is laid.

The egg has a spine or stalk (fig. 1) like those of *M. gibsoni*, *M. pattoni*, and *M. convexifrons*, (Patton and Cragg 1913). It is 3·5 mm. long including the spine, which is about 0·5 mm. long. Two narrow ribs run close together all along the length of the egg, and converge at the tip of the spine.

First Stage Larva. Metapneustic. Faint bands of spines on anterior part of thoracic segment 2 to abdominal segment 7, most distinct on the abdominal segments. The buccopharyngeal skeleton (fig. 2) conforms to the usual first stage type, and has no distinctive features.

Second Stage Larva. Amphipneustic. Anterior spiracles commonly nine-lobed. Buccopharyngeal skeleton as in fig. 3, very similar to that described in *Dasyphora* and *Cryptolucilia* (Muirhead Thomson, 1937).

Third Stage Larva. This has been described by Siddons and Roy (1940). From their descriptions and figures of the skeleton it is evidently very similar to that of *bezzii* and *illingworthi* (fig. 13).



FIGS. 8–13.—*Musca bezzii.* (8) Newly deposited larva. Posterior spiracles. (9) Third stage larva. Posterior spiracles. (10) Newly deposited larva. Late first stage skeleton. (11) Second stage skeleton. (12) Second stage skeleton. Denticles at tip of lateral hooks. (13) Third stage larva. Skeleton.

Musca crassirostris Stein.

This is one of the commonest Muscids on the shoulder sores of cattle in Assam Valley, and is sometimes the only fly seen on these sores. In many cases the flies may be seen gorged with blood, although they are not true biters like *Lyperosia* and *M. inferior*. The habits of the adults have been described by Patton and Cragg (1913).

This species oviposits on fresh cow dung in the field. It appears on the dung shortly after *Lyperosia* and *Gymnodia*, but stays longer than either of these two species. Ovipositing females tend to collect together, and two or three may frequently be seen back to back on the upper surface of the dung cake, ovipositing in the same hole in the dung. These flies together lay one large mass of eggs under the surface of the dung. As many as seven females have been seen clustered together, with wings overlapping, as they oviposited in the same hole, and two more were seen trying to force their way into the bunch.

The eggs, about 2 mm. long, are of the usual *Musca domestica* form, cream coloured, smooth, with slightly concave dorsal surface marked by a pair of parallel ribs.

The larvae are saprophagous and can be reared to maturity on dung alone.

The First Stage Larva differs in no obvious way from that of *M. inferior*. There is nothing distinctive about the form of the buccopharyngeal skeleton.

The Third Stage Larva. Buccopharyngeal skeleton much the same as that shown for *M. bezzii* (fig. 13), except that the left mouth hook is only slightly smaller than the right one. The posterior spiracles (fig. 18) present a distinct appearance, the convolutions of the spiracular openings differ from those of *M. bezzii* (fig. 9) and *M. inferior* (Siddons and Roy, 1940).

Musca bezzii Patton and Cragg, and *M. illingworthi* Patton.

As described in the introduction, these two species were mistaken for one "larviparous *Musca*" in the field. Examination of pinned specimens shows that both species were actually taken larvipositing, and both species reared from larvae dropped in dung. Examination of early stages shows that we are dealing with uniform material, and it seems likely that the behaviour of the two species is identical.

The larvipositing habits of *M. bezzii* in captivity have been described by Patton and Cragg (1913). Later (1922) Patton says that the female deposits one larva at a time on patches of fresh cow dung, and that the newly dropped larva is in the second stage.

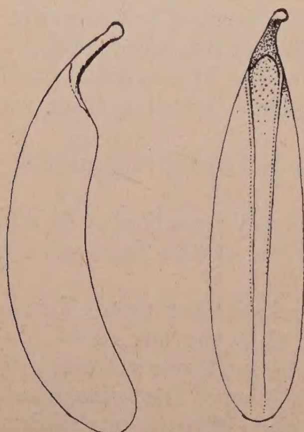
The larvipositing habits of *M. bezzii* and *M. illingworthi* have been observed many times in the Assam Valley. Larvae are dropped on the upper surface of the dung cake, and quickly crawl away into the dung. In one or two cases the discarded vestige of the exochorion was left lying on the surface of the dung, after the manner of *Mesembrina* (Muirhead Thomson, 1937).

Examination of several larvae collected and fixed as soon as they were dropped on the dung showed that they were all late first stage larvae. Under the posterior spiracles of the first stage larva could be seen the incipient second stage posterior spiracles, with two convoluted spiracular slits on each side (fig. 8). Similarly, the anterior spiracles of the second stage are already visible under the first stage cuticle.

The buccopharyngeal skeleton is of the usual first stage type (fig. 10), with rudiments of second stage sclerites beginning to appear. The larvae have well-developed spine bands on the anterior borders of thoracic

segment 1 to abdominal segment 7, and spines are present right round the dorsal surface of the segments, as in *Morellia.*

Second Stage Larva. This is amphipneustic, with commonly nine-lobed anterior spiracles. Spine bands are poorly developed and incomplete. The buccopharyngeal skeleton (fig. 11) is similar to that of *M. inferior* (fig. 3) except for the following features. There is an additional



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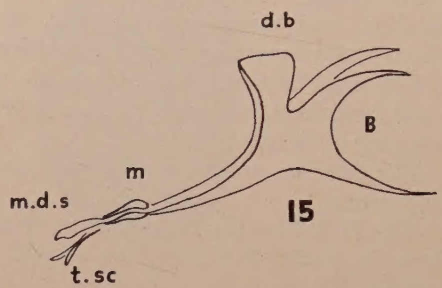

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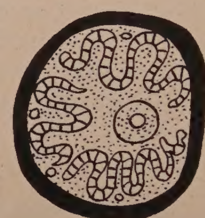

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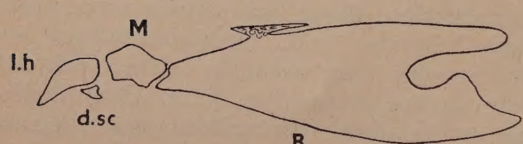

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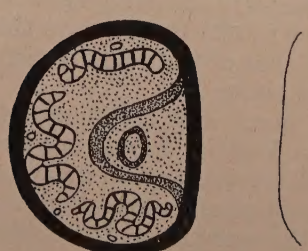

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Fig. 14.—*Morellia hortensia.* Egg.
Figs. 15–17.—*Morellia.* (15) First stage larval skeleton. (16) Early third stage larva. Posterior spiracles. (17) Third stage larva. Skeleton.
Fig. 18.—*Musca crassirostris.* Third stage larva. Posterior spiracles.

pair of sclerites between the angular sclerites and the labiate sclerites. The labiate sclerites are shorter and stouter, while the closely apposed lateral hooks are longer than in *M. inferior*, and have additional minute denticles at the tip. The posterior spiracles are as in fig. 8.

Third Stage Larva. The buccopharyngeal skeleton (fig. 13) has no unusually distinctive features, except that the left lateral hook is shorter and more slender than the right one. The dental sclerites converge slightly ventrally, but remain separate as in most saprophagous Muscid larvae. The anterior spiracles are ten to twelve lobed. Posterior spiracles (fig. 9) heavily chitinised, with spiracular slits much convoluted.

We have no definite record of either of these two species occurring on cattle, although flies closely resembling them have been seen on shoulder sores.

Morellia hortensia Wiedemann.

This is not a particularly common species in the Assam valley. A few may be seen on shoulder sores of cattle and on cow dung, but at times it seems to be completely absent from either of these places.

Oviposition takes place on cow dung, and the eggs may be laid singly scattered all over the dropping, or in small batches.

The egg (fig. 14) is about 1.5 mm. long, and of characteristic appearance due to the fact that the dorsal strip is prolonged anteriorly into a little blunt process. Most of the egg is white with finely sculptured surface, but the anterior part of the dorsal strip has a yellowish tinge. Sometimes eggs are laid in such a way that the anterior process projects above the surface of the dung, in which case they are easily visible to the naked eye.

The larvae of all stages are very similar in appearance to those of *M. simplex* (Muirhead Thomson, 1937) having complete spine bands right round the body, and having the posterior face of the last abdominal segment flattened. As the larvae increase in size the cuticle becomes progressively darker in colour.

The first stage buccopharyngeal skeleton (fig. 15) differs in no obvious way from that of *M. simplex.* No second stage larvae were available. The third stage larva is identical in appearance to that of *M. simplex*, and there are only slight differences in the buccopharyngeal armature (fig. 17). In the full-grown larva the posterior spiracles are so heavily chitinised that the course of the spiracular slits is obscured. But after suitable treatment, or in early third stage larvae, the convoluted slits can be seen more easily (fig. 16). They differ from those of *M. simplex* in having the peritreme complete, and in the degree of folding of the spiracular slits.

The larvae are saprophagous, feeding entirely on dung.

Orthellia indica Wiedemann and *O. lauta* Robineau-Desvoidy.

These metallic green Muscids occupy a position in the Assam cow-dung community corresponding with that of *Cryptolucilia* and *Dasyphora* in Europe.

Oviposition takes place in cow dung, each female laying two or three batches of eggs under the surface of the dung.

The eggs (fig. 4) are about 1·6 mm. long, with parallel dorsal ribs enclosing a dorsal strip which widens slightly at the anterior end.

The First Stage Larva appears to be identical to that of *Cryptolucilia* (Muirhead Thomson, 1937), and there is nothing distinctive about the buccopharyngeal skeleton (fig. 5).

The Third Stage Larva differs from that of *Cryptolucilia* in details. The posterior spiracles (fig. 6) are somewhat similar to those of *Cryptolucilia* and *Dasyphora*, but they are rather more closely apposed, and the sinuous spiracular slits are more convoluted than in those species.

The buccopharyngeal armature (fig. 7) resembles that of *Cryptolucilia* more closely than that of *Dasyphora*. The middle piece is rather different in shape, and there is no trace of the accessory sclerites, near the tip of the lateral hooks, which are distinct but small in *Cryptolucilia*, and well developed in *Dasyphora*.

The larvae are saprophagous.

Lyperosia exigua de Meijere.

This is a common biting fly of cattle in Assam Valley. They have been seen on the head and round the base of the horns, but are usually most common on the flanks, underside, and forelegs of the cattle, usually settle head downwards with the wings open. A few have been seen on shoulder sores and crusted scabs.

Females appear on fresh cow dung almost as soon as it is dropped, and at this time anything up to twenty females may be seen on one dung cake. Eggs are laid usually at the sides or under the edge of the dung cake. Two or three small batches of four to five eggs may be laid.

The eggs are about 1·5 mm. long, and orange brown in colour.

Unfortunately, we have no available early stage material by means of which we could compare this species with *L. irritans* (Thomsen, 1935).

Musca conducens Walker.

We have nothing much to note about this species except that it occurs on shoulder sores of cattle along with *Musca crassirostris*, and has been seen laying groups of eggs on fresh dung.

Xenosia ungulata Stein.

In appearance and behaviour this species corresponds closely to species of *Mydaea* in the European cow-dung community, and a study of the early stages shows that the two genera resemble each other in many ways.

Single females of this species can be seen on fairly fresh cow dung. They usually lay a single egg at the edge of the dung cake, and then fly away.

The egg (fig. 19) is very like that of *Mydaea urbana* Meigen (Muirhead Thomson, 1937) with three anterior pointed processes, the centre process being rather shorter than in *M. urbana*. The egg is 2·5 mm. long, and the distance between the tips of the lateral processes is 1 mm.

The larva which hatches from the egg is in the second stage, amphipneustic, with four to five lobed anterior spiracles, and posterior spiracles which resemble more the first stage type than second stage. There are ventral bands of spines on the anterior margins of abdominal segments 2–7, and there is a well-marked perianal plate.

By dispensing with the first stage, and hatching from the egg with many characters peculiar to second stage larvae, this species resembles *Myiospila*, *Mydaea*, and *Hebecnema* (Muirhead Thomson, 1937).

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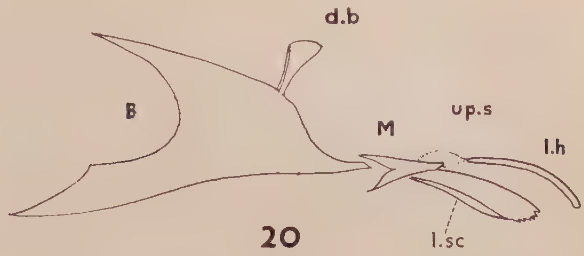

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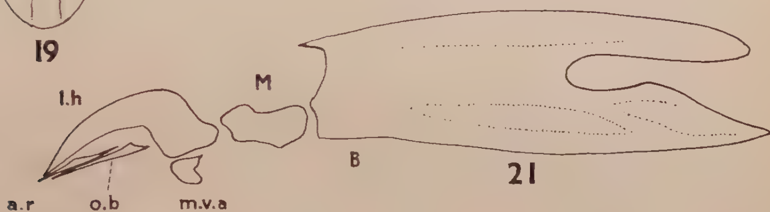

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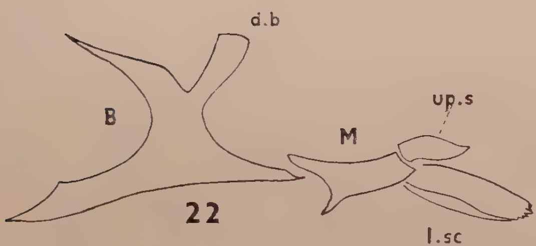

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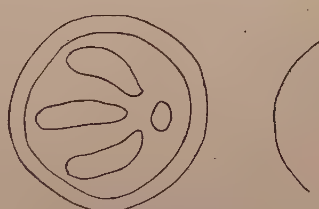

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FIGS. 19–21.—*Xenosia*. (19) Egg. (20) Skeleton of newly hatched larva. (21) Third stage larva. Skeleton.

FIGS. 22–24.—*Anaclyste*. (22) Skeleton of newly hatched larva. (23) Newly hatched larva. Posterior spiracles. (24) Egg.

FIG. 25.—*Xenosia*. Third stage larva. Posterior spiracles.

FIG. 26.—*Anaclyste*. Third stage larva. Posterior spiracles.

The buccopharyngeal armature (fig. 20) of the newly hatched larva also shows many characters peculiar to those species. The basal piece is of stout second stage form with a distinct dorsal bridge. The middle piece has a backwardly-projecting pointed dorsal and ventral process on each side. There is a long sclerite corresponding to the lateral hooks in the second stage *Myiospila* larva, and ventrally there is a broad plate which may correspond to the labiate sclerites of other second stage larvae. In addition there is an unpaired sclerite at the base of the lateral hooks, peculiar to *Xenosia*, *Anaclyste*, and *Gymnodia*.

The Third Stage Larva is very similar in appearance to the carnivorous larvae of *Myiospila*. There are ventral bands of spines on the anterior borders of abdominal segments 2–7. The posterior spiracles (fig. 25) have the spiracular slits nearly straight, and roughly parallel to each other. The buccopharyngeal skeleton (fig. 21) is of the carnivorous type like that of *Myiospila* and *Mydaea* and has no unusual features.

Anaclyste flexa Wiedemann.

This is a conspicuous little fly with yellowish or buff-coloured thorax. In the cow-dung community it occupies a position corresponding to that of *Myiospila* in Europe. The female lays eggs singly on cow dung, and several may be laid in the same dropping.

The egg (fig. 24) is 1·5 mm. long with well-marked flanges which run a nearly parallel course.

The larva hatching from the egg is, like that of *Xenosia*, already in the second stage, amphipneustic, with the anterior spiracles small and usually three-lobed. Posterior spiracles (fig. 23) of first stage type. The buccopharyngeal skeleton (fig. 22) is obviously closely related to that of *Xenosia* (fig. 20). It differs mainly in the form of the middle piece, and in the absence of any sclerite corresponding to the lateral hooks.

The Third Stage Larva differs from that of *Xenosia* in the smaller size of the full-grown larvae, and in having no obvious spine bands on any abdominal segments. The posterior spiracles (fig. 26) have straight divergent spiracular slits. The buccopharyngeal skeleton is identical to that of *Xenosia* (fig. 21).

If kept on cow dung alone the third stage larva remains small, and grows slowly if at all. Its carnivorous habits were established when it was offered full-grown larvae of *Musca crassirostris*, which were immediately attacked despite the great disparity in size. Four full-grown *Musca* larvae were sufficient to bring one *Anaclyste* larva to full growth.

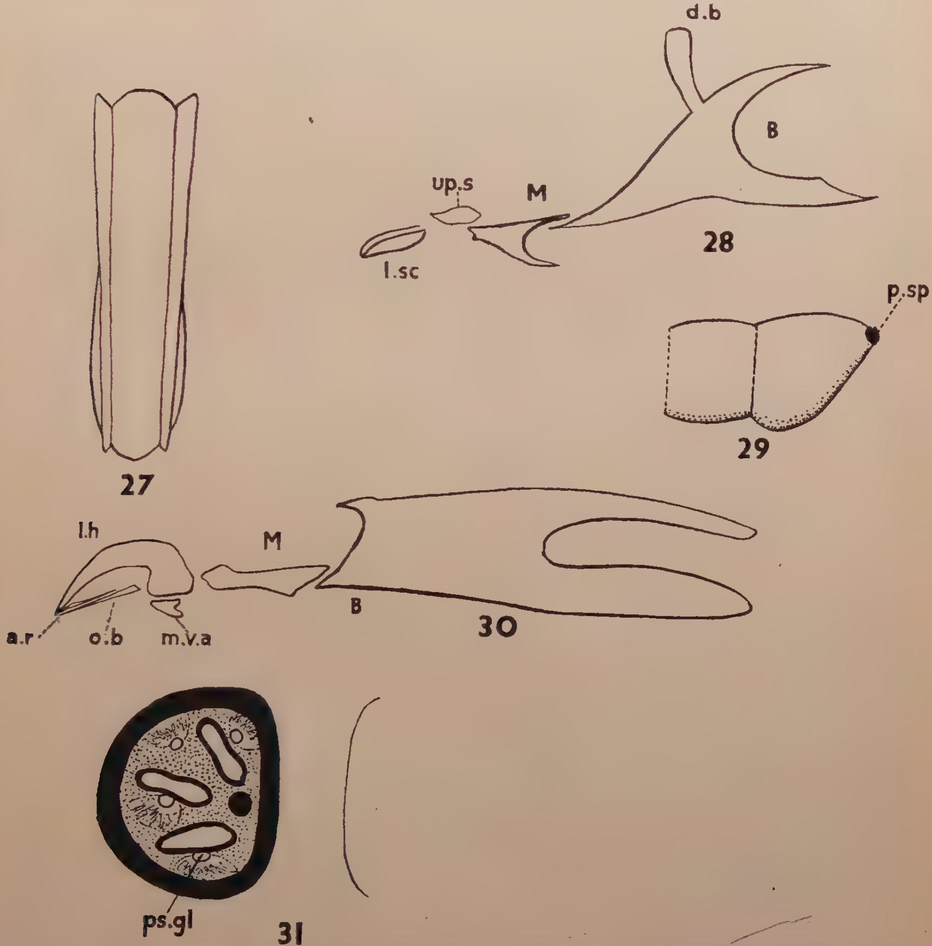
Gymnodia distincta Stein.

This small Anthomyid appears on fresh cow dung and is apt to be confused with *Lyperosia*, and they are both liable to oviposit at the same time. Eggs are laid singly all over the dung cake. They have well-marked dorsal flanges (fig. 27) which run nearly parallel, and are slightly wider anteriorly. The egg is about 1·5 mm. long.

The newly hatched larva, like that of *Xenosia* and *Anaclyste*, is in the second stage. It is amphipneustic with three-lobed anterior spiracles, and small posterior spiracles of a first stage type.

The buccopharyngeal armature (fig. 28) is very similar to that of *Anaclyste* (fig. 22), differing only in the form of the labiate sclerites, and in that the ventral processes of the middle piece are directed backwards.

The Third Stage Larva, apart from its small size, differs from that of *Anaclyste* and *Xenosia* in that the last abdominal segment is drawn out into a point posteriorly, on the tip of which the posterior spiracles are situated (fig. 29). There are conspicuous spine bands on the anterior borders of abdominal segment 2–8.



Figs. 27–31.—*Gymnodia*. (27) Egg. (28) Skeleton of newly hatched larva. (29) Third stage larva. Posterior end. (30) Third stage larva. Skeleton. (31) Third stage larva. Posterior spiracles.

The buccopharyngeal skeleton (fig. 20) is of the same carnivorous form as *Anaclyste* and *Xenosia*, but differs mainly in the elongated form of the middle piece and its sloping articulation with the basal piece. The posterior spiracles (fig. 31) have straight and slightly divergent spiracular slits.

Although we have no direct proof it is almost certain from the form of the buccopharyngeal skeleton, and the obvious affinity to *Anaclyste*, that this species too is carnivorous in the larval state.

Summary and Discussion.

This report is mainly concerned with the habits and early stages of Muscid flies which breed in cow dung in the plains of Assam.

Some of these Muscids are also found commonly on cattle, either as true blood-suckers such as *Lyperosia exigua* and *Musca inferior* or feeding on open sores such as *Musca crassirostris*. Others are rarely seen anywhere else but on cow dung.

Most of the Muscids breeding in cow dung in Assam are oviparous, but *Musca bezzii* and *Musca illingworthi* are larviparous, the newly dropped larvae being in the late first stage.

The larvae of all the *Musca* species in dung, as well as those of *Morellia* and *Orthellia*, are coprophagous with no indication of facultative carnivorous habits.

The larvae of *Anaclyste* are proved carnivores, and those of the closely related *Xenosia* and *Gymnodia* have almost certainly the same habit. These three species also agree very closely in having only two larval instars. The first stage has been dispensed with, and the larvae hatching from the egg are amphipneustic, although the posterior spiracles are of the first stage type. In this they resemble the European *Myiospila* (Keilin, 1917, Muirhead Thomson, 1937) and *Mydaea* (Muirhead Thomson, 1937). Species of these five genera have also much in common in the structure of the larvae, particularly with regard to the buccopharyngeal skeletons, which in the third stage have all the characters peculiar to carnivorous larvae (Keilin, 1917).

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Key to Lettering of Text-figures.

an.s.	Angular sclerite.
a.r.	Anterior rods.
a.sc.	Accessory sclerites.
B.	Basal piece or pharyngeal sclerite.
d.b.	Anterior dorsal bridge.
d.sc.	Dental sclerites.
l.h.	Lateral hooks or lateral crotchets.
l.sc.	Labiate sclerite.
m.	First stage middle piece.
M.	Middle piece, intermediate piece, or hypostomal sclerite.
m.d.s.	Median dorsal sclerite.
m.v.a.	Median ventral arch (*d.sc.* of saprophagous larvae).
o.b.	Oral bars.
p.sp.	Posterior spiracles.
ps.gl.	Perispiracular glands.
t.sc.	t-piece (labium).
up.s.	Unpaired sclerite.
1*st p.sp.*	First stage posterior spiracles.

THE OCCURRENCE OF *ACROTYLUS LONGIPES* (CHARPENTIER, 1845) IN YUGOSLAVIA (ORTHOPTERA, ACRIDIDAE)

By O. Grebenschikov.

(*Serbian Museum of Natural History, Belgrade.*)

On two occasions recently, *Acrotylus longipes* was found in Yugoslavia as an addition to its fauna. It was first taken in August, 1943, near Gevgeli, in Macedonia, close to the Greek frontier, by A. Jukovsky, on the sandy shores of the Vardar river, together with *Acrotylus insubricus* (Scopoli), *A. patruelis* (H.-S.) and *Sphingonotus coerulans* (L.).

The second record, by myself, is of great zoogeographical interest. I found *A. longipes* very numerous in the Banat, on the Pannonian plain, on blown sand dunes along the river Karash, tributary of the Danube, between the villages of Grebenez and Duplaia, near the town of Bela Crkva. The dunes are covered by sparse vegetation, mainly *Euphorbia gerardiana* Jacq. Together with *A. longipes*, there occurred single individuals of *A. insubricus*, *Chorthippus bicolor* and *Calliptamus italicus*. The occurrence of *A. longipes* appears to be connected with the proximity of water, since the species is absent from a very similar and adjoining habitat in the vast Deliblato sand dunes where there is no open water.

The known distribution area of *Acrotylus longipes* extends from Cape Verde and the Canary Islands across northern Africa and the Sudanese zone ; in East Africa, it descends along the eastern coast to the northern semi-desert plains of Tanganyika Territory. Farther east, the species is common in Arabia, Persia and Baluchistan, mainly on the sea coast but also penetrating inland, *e.g.*, to Bampur in Persia and to the Bolan pass, 3,000 ft., in Baluchistan (information supplied by Dr. B. P. Uvarov). In the Mediterranean countries, *A. longipes* is also typical of sea coasts, but again extends inland in some places, possibly along river valleys ; this would account for its occurrence at Gevgeli on the Vardar river (see above), and on a tributary of the Danube at Buzeu in Rumania (Burr, 1898, *Trans. ent. Soc. Lond.* 1898 : 45). On the other hand, the isolated occurrence on the Pannonian plain of the Banat, very far from the sea and separated from it by mountain ranges, is of great interest. It is hardly necessary to postulate that *A. insubricus* has reached the Banat along the rivers, and it probably occurs there as a relic of its Tertiary distribution which extended farther north than its present, essentially African and Mediterranean, area.

It might be mentioned that Rudow (1873, *Z. ges. Naturw.* 42 : 308) recorded *A. longipes*, as well as a number of other southern Orthoptera, from Meklenburg, but these records have never been confirmed and are generally regarded as doubtful (Zacher, 1917, *Geradfl. Deutschl* : 1, 29, 178).

BOOK NOTICES.

South African Insect Life. Vol. 1, 8vo. Entomological Society of Southern Africa, Pretoria, 1945.

The object of this new periodical, which is of a popular nature, is to stimulate an interest in the insect life of South Africa. The first number contains a varied selection of short popular articles on a variety of entomological subjects, two of the papers being in Africaans. The journal should have a wide appeal to amateur entomologists in all countries.

The Hive Bee. By G. A. Carter. 8vo. Worcester (Littlebury & Co., Ltd.). 1947. Pp. 44, 12 pls. Price 7s. 6d.

This little book is more in the nature of a study of the real life of bees than a technical handbook. The author traces the history of Bee-keeping from the earliest times up to the present day, and discusses the scientific knowledge and equipment that have contributed to make the craft an interesting and lucrative one. The following chapter headings give some idea of the scope of the work : Bee-keeping through the ages ; The hive family ; Races of honey bees ; The life cycle of the honey bee ; Stings ; The position of the honey bee in natural economy ; The honey bee in sickness and in health ; Range of the honey bee ; Nectar and pollen flowers ; Nectar and honey ; Honeydew ; Honey as a food ; Wax ; Honey production on the large scale ; and The behaviour of honey bees.

The Louse. An account of the lice which infest man, their medical importance and control. By P. A. Buxton. 8vo. London (Edward Arnold & Co.) 2nd Edition, 1947. Pp. viii+164, text illustrated, tabs. Price 10s. 6d.

The first edition of this work appeared in 1939 and in the interval which has elapsed great advances have been made in our knowledge of this insect, and particularly of methods of controlling it. The medical importance of lice was greatly emphasised by the recent war. A tremendous impetus was given to the study of methods of control, including the use of DDT, so that this section of the present edition has been completely rewritten.

There is an extensive bibliography which covers work published up to the end of 1944.

Butterfly miracles and mysteries. By Bernard Acworth. Illustrated by A. D. A. Russwurm. Pp. vii+260, 1 pl., text illust. 8vo. London (Eyre & Spottiswoode), 1947. Price 12s. 6d.

Part 1 of this work concerns miracles and mysteries. After dealing with the various stages in the development of the butterfly, the author goes on to consider various "miracles" of butterfly life, under such headings as butterfly senses, mimicry, aerial parasites, sense of direction, migration, and instinct.

Part 2 is devoted to life histories and distribution, the insects being dealt with in the following five categories : hardy native residents, hardy native vagrants, non-hardy native migrants, foreign vagrants, extinct native residents. In the case of each species the characters of the egg, caterpillar, chrysalis and butterfly are given.

An up to date list of the British butterflies, a note of the stages in which they hibernate, and an index complete the book. It is illustrated throughout with black and white drawings of each butterfly and its egg.

THE WRITINGS OF I. PORTSCHINSKY ON WARNING COLOURS AND EYESPOTS

By Prof. G. D. Hale Carpenter, M.B.E., D.M.

The interesting writings of Portschinsky[1] on coloration and habits of insects seem never to have received the attention they deserve. An opportunity of translation enabled me to offer the Royal Entomological Society a copy, and as the original papers in Russian, with their illustrations, are in the library, Fellows can now read and enjoy these stimulating observations of an imaginative naturalist. The far-reaching conclusion as to the pictorial representations of long extinct defensive glands emitting droplets of fluid will not be accepted by many, but the ingenuity, and skill, with which the gifted naturalist states his case make delightful reading.

At first Portschinsky discusses what is now known as cryptic coloration, and mentions larvae such as *Chesias spartiata* Fuessley as being dimorphic ; green on leaves of gorse, yellow on the flowers. A larva of *Xylomyges conspicillaris* L. is dark green at first, then yellow on yellow flowers (of gorse) then green again, turning brown when it goes to ground. Other larvae by conspicuous colouring give warning of inedibility. Hairy larvae are eaten by the Cuckoo and Oriole but by no other birds : the chief food of insectivorous birds is hairless caterpillars of sober coloration ; fossorial Hymenoptera, also *Eumenes* and *Odynerus* only select these.

Portschinsky draws an interesting distinction between Ichneumons specific to one larva and those parasitising indiscriminately : the latter are deterred by defences such as hairs valueless against specific parasites adapted to overcome them.

Resemblance to bird droppings is discussed in many larvae and the point is made that in the case of *Drepana lacertinaria* L. all the young larvae are not of the same colour, some are lighter in ground colour but the white parts less intense, others have blacker background and more pronounced white parts. This corresponds with the differences between fresh and old droppings, the weathered examples being lighter and more uniform. [Portschinsky's interpretation shows his insight into a point of fundamental importance—the value of polymorphism in a species resembling a type of object showing considerable variety of appearance. This is very apparent in butterflies resembling dead leaves. Polymorphism results in a greater number of objects having to be examined by an enemy in search of food, and therefore a greater chance that any particular specimen will survive to reproduce its kind.]

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[1] Porchinskii, I., *Caterpillars and Butterflies of St. Petersburg Province.* (*Lepidopterorum Rossiae biologia.*) 5 Pts. St. Petersburg, 1885-1897.

[Part 1 (1885), Drepanulidae, Cymatophoridae, Noctuae (*partim*); Part 2 (1890), Part 3 (1892), Part 4 (1893), Part 5 (1897)—Coloration marquante et taches ocelées, leur origine et leur développement.]

In the case of *D. lacertinaria* the importance of attitude is stressed: the young, bird-dropping-like larva adopts a twisted attitude which accentuates the resemblance, but as it grows larger and becomes like a birch-catkin this attitude is given up. [One of the chief merits of Portschinsky's writings is his insistence on attitude as well as coloration.] But the actual markings remain throughout; the caterpillar maintains an unbroken transition. [Readers will be reminded of Poulton's demonstration in 1902 that the change from a wet season to a dry season form in *Precis* involves no new markings, merely the accentuation or reduction of those already existing.] The appearance of the entrance to a shaded tubular cavity of a dead leaf is represented in the larva of *Thyatira batis* L. by a darkly shaded space under forwardly directed appendices on the second segment.

It is not clear from Portschinsky's writings whether he was aware of the hypothesis of Müllerian (synaposematic) resemblance put forward some six years previously, but the following is significant as a possibly independent statement of that idea. Similarity between caterpillars of different groups is due to the fact that in distasteful, brightly coloured larvae with sparse hairs there is a tendency to assume protective [*i.e.*, defensive] colours already existing in nature instead of acquiring new ones unfamiliar to enemies. Portschinsky then proceeds to discuss what he terms "Bright protective colouring," dividing caterpillars with bright coloration into two groups, hairy or prickly, and naked. The former are often marked with one or two colours, but other bright caterpillars have diverse coloration different from the general ground colour: this type Portschinsky calls "Light protective colouring." The larva of *Abraxas grossulariata* L. and a number of others are discussed from this point of view: the light protective colouring depends upon an orderly combination of black, yellow and white, often with the addition of some red. Special significance is attached to the larva of *Papilio machaon* L., whose adult larva is greenish-white with orange and black markings, of the same general type as those of *Cucullia scrophulariae* Hübner or *Zygaena scabiosae* Esper. But the quite young *Papilio* larva is very different and only at this stage does it protrude its osmeterium. The gland loses its significance as the adult stage is reached—what does the larva gain in its place? It acquires "Light protective colouring." Portschinsky notes it as significant that aberrant larvae of *machaon* which change little in colour, and may remain black up to pupation, retain full use of the osmeterium even in the last stages. [Is this generally true?] Sawfly larvae are next considered as in two classes, those with concealing colours living in rolled-up leaves, and those brightly coloured and inedible. *Lophyrus pini* L. larvae are quietly coloured but their gregarious habits make them sufficiently obvious. When aroused they raise the forepart of the body and emit fluid from the mouth. *Lophyrus similis* Hartig, however, is solitary and has "light protective colouring." The body is whitish, with yellow spots on raised tubercles resembling drops of yellow liquid standing out from the body. [Here Portschinsky introduces the subject which he eventually develops very far.] *Cimbex* larvae are remarkable for squirting out a liquid secreted by lateral glands: many are light green with white spots and a blue or black

dorsal stripe. But *C. humeralis* Leach has most pronounced "light protective colouring" ; the body is white with black and orange spots. On the strength of Snellen's statement that he has not seen this larva squirt out fluid, Portschinsky concludes that in this species "light protective colouring" is taking the place of the ability to eject fluid, and points out the saving gained by not having to manufacture quantities of the fluid. The larva of *Abia fasciata* L., closely related to the last, has "light protective colouring" : it cannot squirt out fluid, but, when it is touched a drop of liquid appears at the orifices of glands. This "light protective colouring" has replaced the ability to eject the secretion to a distance. The larvae of *Nematus melanocephalus* Hartig and *N. cadderensis* Cameron are greenish-white with lateral orange spots fringed above and below by black spots. To disclose these spots the larvae lie on their sides, the end of the body bent into a ring ; this is beaten up and down when disturbed. They emit neither liquid nor odour, but the yellow spots, on projections over the spiracles, give the appearance of drops of bright yellow liquid standing out from the body. The larva of *Nematus septentrionalis* L. is almost white, the first and last segments bright yellow : the dorsum of the middle of the body is without markings. The sides have black, but no yellow, spots, but the pseudolegs make up for this. Green glands secreting disagreeable fluid occur along the mid-ventral line and protrude when the larva is alarmed. It then turns upwards and forwards the whole posterior half of the body so that its dorsal surface almost touches the anterior dorsal surface. There are now seen the two rows of bright yellow legs, strongly reminiscent of drops of yellow liquid, standing out from the body. In young larvae, which are dull coloured, the legs are not yellow. The yellow of the end of the body and of the prolegs is the last to appear : when it does, the glands cease to function. The larva of *Nematus pavidus* Lepeletier holds up the rear end of the body like that of *septentrionalis*, but differs greatly in colour, being dull green and black. But the glands, even in adult larvae, give off stinking fluid and the glands themselves, as well as the prolegs, are yellow. In very young larvae only the glands are yellow. Portschinsky remarks that the different powers of these three *Nematus* larvae when adult are due to different development of protective colouring on their bodies.

He then considers Coleopterous larvae. *Lina tremulae* Fabricius when very young are almost entirely black and gregarious. They disperse as they grow and then turn pure white with six black spots across each segment, but no yellow. The yellow is replaced by exudation of strongly smelling fluid, in drops, from conical tubercles, giving the appearance of spots. The larva of *Coccinella oblongoguttata* L. is whitish with black spots and orange-yellow markings, and spots standing on black tubercles so as to resemble drops of liquid. It cannot now eject fluid, but that it formerly did so is shown by squeezing it, when droplets of orange-yellow liquid stand out. Here, again, complete development of light protective colouring corresponds with disappearance of the ability to eject protective liquid.

Portschinsky then passes on to elaborate this thesis with other larvae. Light protective colouring has three components—a very pale

ground colour with black spots, and spots or stripes of yellow closely associated with those black spots : these yellow spots are frequently placed on small protuberances so that they resemble droplets of liquid standing out. Pupae being helpless, urgently need protection, and in some cases such as *Leucoma salicis* L. a transition is shown to light protective colouring : it is whitish with large black spots, and thick tufts of hair make up for lack of yellow. *Aporia crataegi* L. has light protective colouring and at the cephalic end has an appendage, orange-yellow and truncated, surrounded by black, resembling a drop of bright yellow fluid exuding.

Portschinsky, in one of his most imaginative passages, then describes in great detail the highly peculiar pupa of *Limenitis populi* L. His conclusion is that the rounded protuberance standing out from the base of the abdomen, orange-yellow with black spots at the base, shiny and semi-transparent, is like a drop of yellow liquid oozing from the body. This is to represent a pupa which has been attacked by a bird and left as distasteful, but damaged so that the contents exude. [I have seen this in the case of the pupae of *Zygaena filipendulae* L.]. Pupae were tested on a turkey but, although torn to pieces, no part was eaten. This is quoted as an example of "light protective colouring" in which, instead of a series of droplets of orange fluid oozing from black tubercles, there is one large orange protuberance, margined with black spots.

The pupae of the Chrysomelid *Lina tremulae* are next considered. The larva is black with white spots and the pupa makes good the lack of yellow by utilising droplets of the odoriferous fluid left behind in the larval skin which shrouds it. The pupa, if disturbed, raises itself vertically and forces out drops from the larval skin, which are reabsorbed when the pupa sinks back into place : since the pupal stage only lasts five days the store of fluid is sufficient.

Light protective colouring in butterflies and moths is then considered. A number of moths are quoted with orange, black, and white markings. Attention is drawn to the behaviour of *Spilosoma mendica* L. which is noted to be most tenacious of life and to live for days in a jar with Prussic acid fumes. [This early recognition of the resistance of aposematic insects to chemical poisons is most interesting.] When disturbed it falls to the ground so that the ventral surface is uppermost, displaying the yellow femora held close to the body so that they form a yellow patch bordered by the black tarsi and black on the head. This moth is compared with *Spilosoma urticae* Esper, also white but with part of the upper surface of the abdomen yellow, and only the first pair of femora yellow. When alarmed, *S. urticae* curves its abdomen downwards, and the front pair of femora are stretched out : thus it displays its light protective colouring.

Portschinsky then discusses the under surfaces of a number of butterflies, and expresses surprise that the bright protective coloration appears to have been overlooked by writers, which is the more surprising as we meet with it at every turn—*e.g.*, *Syricthus sidae* Esper, many Lycaenidae such as *Lycaena battus* Hubner, *Melitaea cinxia* L., *M. didyma* Esper, and *M. arduinna* Esper. So far only the meaning of the yellow has been explained.

How has protective exudate come to be replaced by tubercles projecting to resemble droplets of liquid, or even by a simple flat pattern of the same colour as the fluid ? The immense amount of fluid secreted, as in the case of *Lina populi*, makes great demands upon the organism. When the appearance of an inedible insect has become well known to enemies it is no longer necessary to secrete or store large quantities of protective fluid, and nature gradually decreases the power to secrete, replacing it with a special type of device. Among sawflies the imagines of *Tenthredo scalaris* Klug and *T. obsoleta* Klug when seized emit fluid from the anus. *Hylotoma pullata* Zaddach protrudes a spherical green object which looks like fluid but is the prolapsed rectal lining ; a slight smell is produced on the first occasion only. In other words, the secretion has greatly diminished, but the gland itself bulges out. A further simplification is seen in *Tenthredo* and *Allantus* in which the bulging gland is replaced by a coloured spot giving the same appearance. A spot at the end of the abdomen is very common in Ichneumonidae, and they display it by movements of the abdomen up and down. These spots remain as a reminder of the former yellow or white exudate. Secretion of protective liquid can only be expected to occur in insects that have no protective marks, since the latter take the place of fluid. Again, the beetles *Lina tremulae* when handled exude a liquid along the sides of the thorax and elytra which becomes opaque, outlining the beetle by lateral stripes. Chrysomelid beetles often have such markings, presumably representing a former exudate. Portschinsky ingeniously supports the argument by comparing larvae of *L. tremulae* and *L. aenea* L. The former emit copious white exudate, and their bodies are white : the exudate could not be replaced on the white body since substitute markings are of the same colour as the liquids which they replace : therefore yellow is lacking in *L. tremulae*. But *L. aenea* larva is greyish with black tubercles secreting white, strongly odoriferous fluid. The pupa is of the same colour but has two pure white tubercles on the thorax resembling two protruding drops of liquid. These protective marks do away with the need for utilising the exuvium of the larva as does *L. tremulae*.

Various species of Coccinellidae are then considered from the point of view of whether they do or do not exude fluid, and the correlation of their coloration and habits with this. To sum up—there are three phases in development : (1) Protective fluid is emitted at every threat ; (2) protuberances are developed which resemble the drops of fluid they supersede ; (3) a simple spot forms a picture of the drop formerly secreted.

Next Portschinsky considers eye-like spots, and at once states his belief that their protective value lies in their suggestion of drops of liquid. A tubercle emitting fluid is, as previously shown, represented by a yellow spot surrounded by black. Nature represents solidity by shading ; thus, in eyespots as in *Parnassius* the pale centre represents the centre of a drop of opaque liquid of which the colour is shown by the periphery. If on the other hand the liquid is colourless, all the middle will look dark and the colour will appear at the periphery of the drop : there will be at the centre of the dark part a white dot representing reflected light, as in Satyridae. The orange ocelli on Lycaenidae have bluish scales on one

side : the ocelli correspond with the lustre on a liquid surface, the bright blue being equal to the reflection of the blue sky on the surface of a round drop of liquid.

The eyespots of *Aglia tau* L. and *Papilio machaon* are then discussed in detail, with their special peculiarities imaginatively explained. Portschinsky summarises by saying that eyespots, like light protective colouring, arose originally only on caterpillars and were transferred thence to butterflies' wings when they reached their highest development. They could not appear there until protective markings had replaced protective fluid on the caterpillar, because wings of butterflies, that cannot secrete protective liquid, are incapable of evolving protective markings independently.

The next development of these interesting ideas concerns the striations and ribs along the elytra of beetles.

It was shown earlier how exudates, appearing along the edges of the elytra, may produce a definite pattern of longitudinal belts, and then may appear along the length of the elytra. Carabids may have longitudinal ribs in low relief, and white designs in longitudinal rows : on *Graphipterus* and *Anthia* the design is in spots. In Tenebrionids there may be rounded swellings, or continuous longitudinal ribs, or (as in *Sternodes*, *Platyope*) longitudinal white belts. Now sculpture and colouring are often biologically interchangeable, and since these white spots and belts are expressions of the same coloured liquid, it may also well be shown plastically by sculpture. We can reproduce the various *Carabus* sculptures by spreading water with a brush on smooth elytra. *Carabus violaceus* L., with four rows of drops, can be made to look like *C. hortensis* L. *Carabus splendens* Fabricius, *auronitens* Fabricius, and *lineatus* Dejean are arranged in series to show the three stages of smooth shiny surface without design, but with actual emission of fluid ; the fluid is represented by swellings or ribs ; the ribs are replaced by flat belts of colour.

Portschinsky then extends his principles to butterflies such as *Danaus chrysippus* L., but finds it necessary to discount the importance of the general yellowish-brown colour in his scheme. He stresses the narrow black border with white spots, and suggests that these spots again represent protective fluid. Since the wings produce no fluid the design is borrowed. But the body still contains the light-coloured fluid which was the first defence and remnants of the fluid-producing glands are still represented on the black body by rows of white spots. This design has moved from the body to the wings.

Portschinsky next considers the system of warning by cross-belts of colour, a black body with transverse yellow stripes. He supposes that such larvae were originally black and lived on the ground by day, climbing up to feed by night. This was wasted energy : they developed a defensive system of glands making a yellow cross belt on every ring as the frightened larva curved into a ball. Such rings to represent liquid are shown in the larva of *Clidia geographica* Fabricius in which the intersegmental membrane is bright orange. In Lasiocampid larvae the transverse clefts on the thorax open and show the sudden spouting of liquid. All these phenomena of bright coloured belts or spots suddenly

shown as a reminder of defensive liquid would lose all meaning if they did not show that once there was liquid there.

After discussion of the colour scheme of the larvae of *Euchelia jacobaea* L. and *Zygaena scabiosae* Scheven, and comparison with Mylabrid beetles, Portschinsky suggests that the Cinnabar moth has borrowed its coloration from beetles : the dark wings with red belt are reminiscent of *Lina* producing liquid along its margins ; this has been replaced by coloured warning belts. A significant passage points out that there are different systems of warning colours, some being useful against one enemy, some against another, but warning colour as a means of defence is not an absolute safeguard against all kinds of insect eaters. The theme of borrowed colours is pursued at some length for different moths, and Portschinsky passes on to consider changes in defence coloration as shown by larvae of *Saturnia pyri* Schiff. and *S. pavonia* L. : he concludes that the differently coloured tubercles are substitutes for coloured defensive liquids, with different effects on different enemies, which is true of all warning markings. Changes in relative numbers of different enemies, and in their tastes, are offset by changes in warning colours. A Japanese species, *Attacus ïama-may* Guérin, at first has yellow tubercles, later replaced by blue tubercles, and at a later stage all tubercles disappear and the larva has shining silver spots circled with black—*i.e.*, substitutes in flat design for drops of fluid. In *Attacus pernyi* Guérin of China there are silvered tubercles as well as the flat spots so that the body seems sprinkled with dots of dew or other liquid. The sham globules are an indication that the caterpillar is inedible because of defensive fluid, whereas the flat silver spots represent the defensive fluid itself and there is no need for indicators such as the globules.

Warning colours on wings of Lepidoptera are then considered. Camouflage, or revealing colours, are naturally always placed on parts that are visible. The lower surfaces of wings of Noctuidae have uniform background without any design. In butterflies which erect the wings the coloration is often different on the two surfaces. But the part of the fore-wing projecting beyond the hind-wing carries the same coloration on the underside as the hind-wing. Since, also, in many cases the coloration on all wings is alike above and below, as in *Danaus*, we can assume that originally to have been the case as a general rule, with both surfaces uncovered when at rest. The habit of pressing the wings together would be a later development. Thus, warning colours are remnants of a scheme that once showed on both wings equally, but many species found they were better off if the warning colours were replaced on the under surface of the hind-wing by concealing colours. [This is not in keeping with the true theory of warning colours which could not come *before* cryptic colours, seeing that they depend for their preservative value upon presence of cryptic and more edible species.] Great changes have occurred on the under surfaces of the hind-wing : some have well-marked warning colours, others have developed camouflage or there may be warning markings quite different from the vestiges remaining on the upper surfaces, and the lower surface of the front wing. Such changes show that a warning scheme is not a constant defence against all enemies at all times. An increase in one or other of the enemies, or a

change in their taste, alters the situation : the coloration is changed, when its effect weakens, for one more effective at that particular time.

Portschinsky then extends his doctrine of "borrowing" to resemblances between the coloration of butterflies and caterpillars—*e.g.*, *Melitaea didyma* Esper, and the larva of *Cucullia balsamita* Boisduval, of which he says the central rings are not different from the wing design on *M. didyma.* In America *M. chalcedona* Doubleday has a design very like that of the larva of *Leucoma salicis*. *Melitaea phaeton* Drury of U.S.A. has on the underside of the hind-wing a colour scheme like that of the larva of *Pygaera bucephala* L. The fact that the latter two larvae do not occur in U.S.A., in Portschinsky's eyes only accentuates the argument based on the fact that such warning colour schemes occur in larvae from entirely different groups as well as on the wings of butterflies from distant parts of the world. *Melitaea phaeton* differs from most Melitaeas by the under surface of the hind-wing not differing from other wing surfaces, while the upper surfaces are like those of other Melitaeas —*i.e.*, *phaeton* retains on the lower surface the older warning coloration common to other Melitaeas. This coloration, found in Europe, Asia and America, was borrowed from caterpillars which had produced this scheme earlier : only a few survivors are now left—*e.g.*, *Melitaea phaeton*, the larva of *Pygaera bucephala* and the larva of the Sawfly *Hylotoma pullata* Zaddach. The coloration of the larva of *bucephala* is also found in other larvae living on tree-lichens (the Syntomid *Nadia ancella* L.) or rock lichens (*Setina aurita* Esper and *irrorella* L.) : such simple black and yellow schemes might have begun as cryptic coloration on lichens. When such larvae began to produce defensive liquid, and could lead a more open life, these colours, on green leaves, became warning coloration.

Portschinsky then applies his ideas in detail to various species, and his speculations give free play to the imagination. *Charaxes jasius* L., for example, has the design on the under surface cut into two halves by a white belt. The outer part of the design is referred to a larval pattern of yellow and black with red spots, and the tails correspond to tufts of hair. The basal part of the design, of rust-red and white, is held to be of the same nature as the designs on the elytra of beetles such as have already been considered. The pattern on the body of the butterfly, continued on to the bases of the wings, represents spots of defensive fluid. The pattern on the outer part is reckoned to be an older type of coloration, picturing a black and yellow larva with its background of lichen and cracks on the tree trunk. *Papilio machaon* has colouring like the larva of *Acronycta euphrasiae* Borkhausen. The first segment of this larva is so much more vividly coloured that it once probably had the glands to secrete the orange defensive liquid. When enemies learned to avoid this caterpillar on sight the liquid changed to spots of the same colour. The orange spot on *machaon* is an imperfect "eyespot" ; a substitute for a drop of defensive liquid.

Portschinsky next elaborates still further his principle of the importance of warningly coloured fluid, and draws attention to cases in which it not merely oozes out, but is forcibly ejected. The larva of *Aglia tau* after the second moult has a mark on the fourth segment appearing,

when the larva is disturbed, as a dark oval cavity with a red rim bordered by white. The larva now has no defensive fluid, but it is claimed that this red mark is a relic of this protection : at one time, when the pit opened, liquid spurted out. When this property was thoroughly known to insectivores the liquid ceased and only the warning mark remains. [This supposition assumes that knowledge is handed on to the offspring.]

The so called "eyespots" on the wings of Saturniids are discussed, and Portschinsky thinks that these warning marks have crossed from the body of a caterpillar to the wings of a moth—just as savages paint on their bodies the heads of creatures with some obscure meaning. How did this process develop ? Bodies of larvae with concealing colour schemes often have belts which to some extent mask the bodily form and may be quite bright in colour, but this bright colour is a normal part of the surroundings. It was along such belts that the gland for defence first developed in the situation now shown in *A. tau*. The belt in *A. tau* is here white, but there are red lines elsewhere which suggest that the belt was once red in the middle and white on the sides, as now in *Calocampa exoleta* L. Thus, when the pit developed in the belt it was edged with red, and with white beyond. When the pit began to assume warning functions the red vanished from the belts, when the white was better seen and remained only as a ring around the pit. The theory of markings representing glands on the undersides of butterflies' wings is developed, and part of the wing of *Papilio emalthion* Hübner is figured to show how minute spots represent actual droplets of fluid supposed to have been ejected from the representation of a gland. The underside of *Papilio homerus* Fabricius from Jamaica is discussed, and Portschinsky finds a whole row of pictured cavities or plates which once produced liquids but are now warning signs. Opposite every pit, towards the base of the wing, is seen a sheaf, sometimes double, formed from a number of bluish or white points ; these are the tiny drops from the pit, and represent a watery spray fallen on the wing. The underside of the N. American *Papilio troilus* L. female well shows the effect of minute droplets of spray: the orange spots recall the warts on larvae such as *Orgyia antiqua* L. The "eyespot" of *Vanessa io* L. has subsidiary small spots to represent minute droplets of sprayed fluid. In *Papilio paris* L. the spray is pictured as having been thrown further than in any other species, leaving room for a broad black intervening space with few points.

The importance of fluid for warning purposes is taken still further when sound production by insects is considered. Portschinsky remarks that fluid strongly spurted out makes a sound especially if it strikes against something. Quite probably sounds emitted by insects at moments of danger are meant as a warning of the presence of defensive fluid. *Mantis religiosa* L., which in defence stridulates, has on the inner surface of the base of the front femur a large blue spot inside a black ring. Certain spiders when on the defensive open wide the jaws, showing at the tips drops of liquid, and one species, when attacked by a Pompilid, was noted as pouring out poison drop by drop in amount sufficient to wet the place on which it stood. Possibly the use of sound supplemented the fluid when this became scanty, and may have been useful against night attack.

An ingenious allusion is made to the large and often brightly coloured heads of larvae of HESPERIIDAE which live in rolled-up leaves: the head at one end of the roll represents a Coccinellid or Hemipteron which has crawled into the tube. Portschinsky remarks that this is a most interesting form of mimicry in which only the head takes part.

Eyelike markings on Sphingid larvae, such as *Ch. elpenor* L., are said to be like the top of a pit, black, and marked off by a white line: there seems to be a transparent defensive liquid on the surface showing a glitter like mother-of-pearl. It is claimed that the wide distribution of such marks, on larvae and on wings, indicates that they are "borrowed": this is supported by the fact that they may differ greatly in specimens of one species. If a caterpillar evolved its own markings such differences would be unlikely.

There is a long and rather complicated discussion as to what is the original caterpillar supposed to be represented, and it is again stated that tails on the hind-wings of butterflies picture hairy outgrowths from larvae.

After reproducing a figure of the extremely hairy larva of *Megalopyge orsilochus* Cramer, Portschinsky makes an astounding comparison between the pattern of the marginal parts of the wings of a Saturniid *Dysdaemonia pluto* Westwood and a figure of the hairy larva of *Tolype* given by Burmeister. Another comparison is made between the larva of *Anurocampa mingens* Herrich-Schaeffer, which has expanded anterior segments across which there is a warning mark in red. A large Saturniid moth, *Arsenura hercules*, has a design on the margin of the front wing in its general features like that of the caterpillar. Other examples of caterpillars pictured on the wings of moths are cited, and Portschinsky even says that Saturniids show many cases of a single moth bearing representations of different caterpillars on different wings.

Referring to Sphingid larvae and Poulton's work, showing that the horn is in form and growth in the young larvae as in *Aglia tau*, Portschinsky suggests that these growths once produced defensive liquid. In *Philampelus crantor* Cramer (*achemon* Drury) the horn is finally replaced by an eyespot. In *Philampelus labruscae* L. segment eleven in place of a horn has a round eyespot in which the centre constantly changes shape. As stated by Merian, it appears as "une pellicule blanche, brillante comme le cristal et qui s'elevait et s'abaissait." Portschinsky describes it as a dark plate from a cavity in which an apparent drop of liquid in the form of a shining white membrane ebbs and flows with a gleam that reminds us of transparent crystal.

The coloured hind wings of *Smerinthus ocellatus* and other Sphingids are discussed. Similar black-bordered red wings are used as warnings by the S. American Orthoptéron *Rhomalea microptera* Charpentier. This cannot fly, but defends itself from pursuers by a display of the warning colour on its wings, which are normally hidden under the tegmina. The complex red, yellow, blue, black and white colour on the hind-wings of *Philampelus labruscae* is derived by Portschinsky from a similar complex on the dorsum of the fourth segment of the larvae. *Amphonyx cluentius* Cramer has a hind-wing pattern of black, yellow and white matched by a similar coloration on the last two segments of the larva of

Anurocampa vomax L. described by Burmeister. This, when disturbed, raises the posterior extremity upwards and forwards so that yellowish, black and white patches appear as they do on the moth of the other species.

Portschinsky in his last part then considers secretory glands ("neck glands") in many larvae (*Vanessa*, *Melitaea*, *Argynnis*, *Bryophila*, *Plusia*, *Leucania*, *Sesamia*), but not in Geometridae, Bombycidae, Sphingidae, Liparidae, Arctiidae, Saturniidae. The gland exists in some Notodontid genera, but not in others.

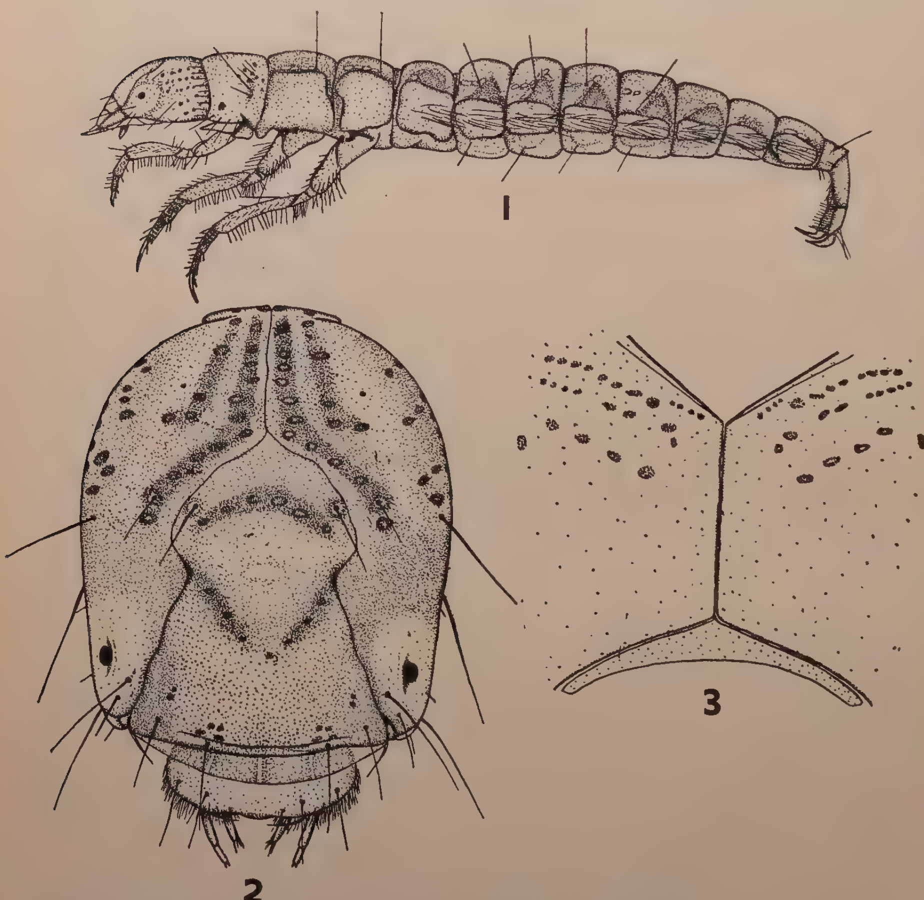
The brightly coloured posterior lashes of *Harpyia vinula* L. are then discussed and are said to be reminiscent of the coloration of the hind legs of many Acrididae. The tarsus of *Stethophyma fuscum* Eversmann is coloured yellow, black and red, the young larva of *Aglia tau* has long thin outgrowths brightly coloured in the same way, and it is said that there is reason to believe that they once produced defensive liquid. The likeness between the hind legs of the Acridian and the filaments in *Aglia tau* depends upon the power of the latter to produce a repellent fluid. Acrididae have never had such powers, but found the disguise useful as a protection. [It is now known that many aposematic Acrididae not only possess defensive fluid but emit it forcibly as copious yellow froth.] The lashes of *H. vinula* have the same coloration, and it is also found on the bodies of insects which have glands. Formerly these glands and their associated tubercles were widely spread in nature, that is why they are so well known to insectivora. The coloration passed by natural selection to the hind-wings of Acrididae, but these have no poisonous properties or glands ; the latter have come down to us only in the early stages of caterpillars. Thus the Acridian coloration is losing its significance, but even today some show the coloration on the hind legs. The colour of the legs is used as a warning by *Eremobia muricata* Pall., a sedentary earth-like species. But the inner surface of the hind femur is violet at the base, passing to red at the end : the tibia is lilac internally but red, with red spines, above. If disturbed, *Eremobia* gives one or two jumps, but then stops suddenly and lifts its hind legs, turning them outwards to display their bright inner surfaces, remaining thus for some time. It also bends down the head to show the posterior violet surface, and makes a stridulating sound. The bright coloration of the hind wings seen in flight is considered, and the explanation put forward that the pursuer, with eyes fixed on some particularly bright colour on the wing, continues to look for this, and losing sight of its prey abandons the chase.

Finally, the remarkable larva of *Stauropus fagi* L. is discussed at length, with its behaviour, and Portschinsky considers that the full-grown specimen, when disturbed, resembles a dying insect being sucked by a Hemipteron on top of it.

LARVAE OF THE BRITISH TRICHOPTERA, 23

By N. E. Hickin, Ph.D., F.R.E.S.

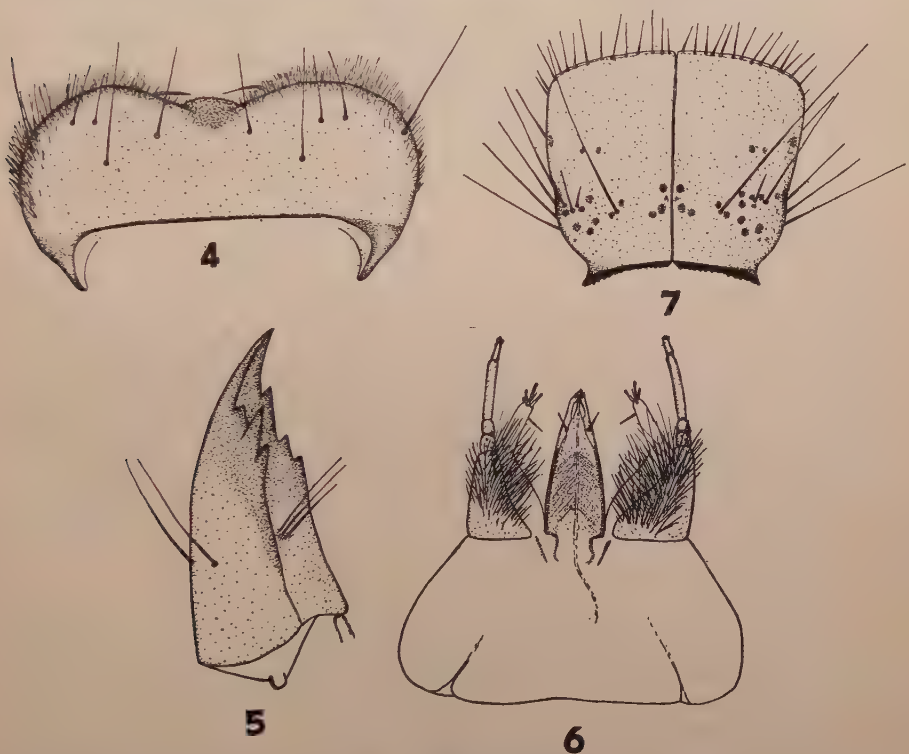
Plectrocnemia conspersa Curtis (Polycentropidae).



Figs. 1–3.—(1) Larva (lateral view). (2) Head. (3) Gular sclerite.

Larvae of this species were collected from a fast stream at South Nutfield, Surrey, and also from Painswick, Gloucestershire; Dowles Brook, Bewdley, Worcestershire; Wilderhope, Shropshire; Sutton Park, Warwickshire, and several localities in Westmorland. Larvae from the Surrey locality were reared to the adult stage for the species determination to be confirmed. Some of the streams from which larvae were collected were nothing more than small trickles running over or round stones or flat pieces of rock. Under the latter a silken web is

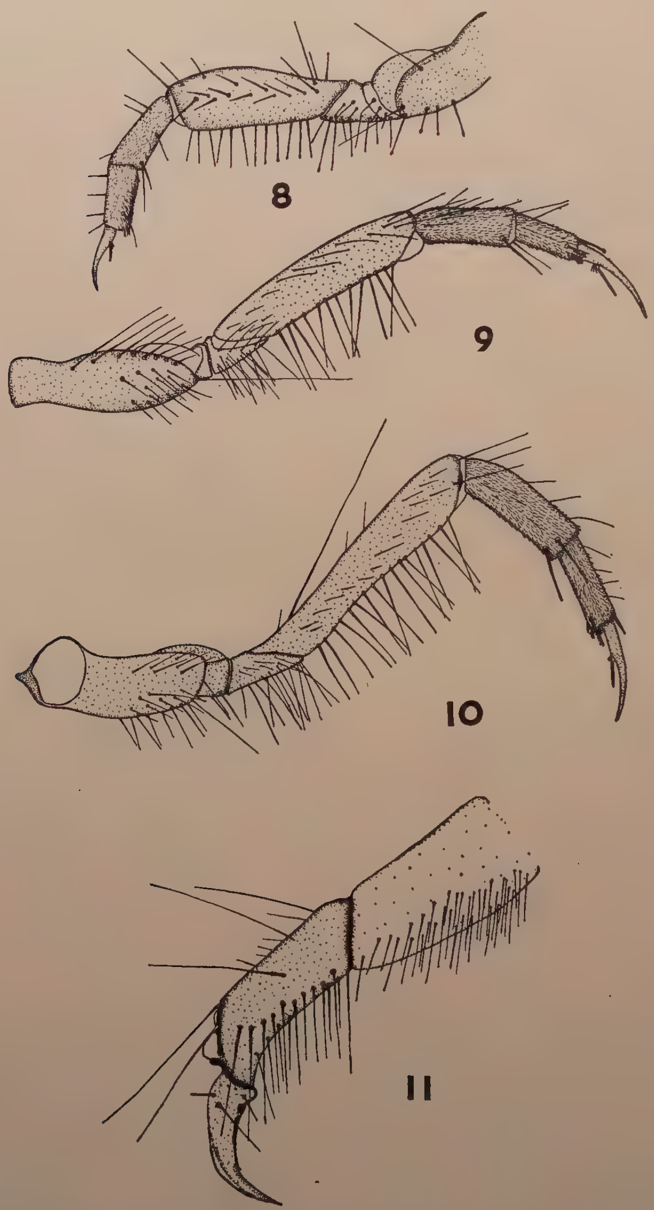
secreted by the larva for snaring small animals. This consists of a tubular central part and a funnel-shaped entrance and sometimes exit. If the larva is made to suffer a major disturbance of its habitat it will swim by undulating its abdomen in the vertical plane. When transferred to an aquarium, the larva, after a survey of suitable sites, rapidly constructs a new shelter and snare. It was often found that the larva would desert, for no apparent reason, its newly constructed shelter and build another one. It can run rapidly around its web, occasionally doubling back, and all its movements are precise. From time to time the abdomen is undulated in the vertical plane with the effect of maintaining a current of water over the body for oxygenation. Although the larvae are taken from running water it is easy to rear them through to the pupal stage in an aquarium, but a high proportion die as pupae at the swimming stage immediately before emergence as adults.



Figs. 4–7.—(4) Labrum. (5) Left mandible. (6) Maxillae and labium. (7) Pronotum.

Larva (fig. 1) campodeiform, without a case. Up to 22 mm. in length and 3·5 mm. in width. Widest at about the third and fourth abdominal segments. Deep intersegmentation of abdomen. Colour greyish-brown to reddish-brown with a lighter band running longitudinally along dorsal surface of abdomen. A pattern of light spots and dark areas is present. *Head* (fig. 2) procentrous, yellowish-brown to reddish-brown. Prominent ridges for insertion of head into prothorax. Oral end of clypeus long, narrowing more or less gradually towards aboral end. Light mark in centre of aboral end of clypeus, towards middle of clypeus a "V"-shaped line of fainter dark marks. These marks are the "fourteen spots" of previous

authors ; an additional spot may, however, be present in the centre of the oral group. A fold runs parallel with the anterior margin of the clypeus with a group of four dark spots at each end. Preclypeus faintly divided into four by three longitudinal pale marks. On the genae a row of dark marks adjacent to each side of median suture ; these diverge anteriorly and lie adjacent to aboral end of clypeus. A fainter row of marks runs outside each of the rows. Antennae rudimentary, eyes near anterior end of head. Gular sclerite (fig. 3) very



Figs. 8–11.—(8) Prothoracic leg. (9) Mesothoracic leg. (10) Metathoracic leg. (11) Anal appendage.

narrow, anterior margin concave. Postgenae contiguous for considerable distance. *Mouthparts* : Anterior margin of labrum (fig. 4) hairy, concave with a cushion-like protuberance in the centre. Mandibles acute, strongly toothed on inside edge. Left mandible (fig. 5) has "brush" of about three bristles on inner edge. This is absent in right mandible. Maxilla (fig. 6) hairy at base, maxillary palp four-segmented, third segment long. Labium acute, partially sclerotised on outer margins, well defined spinneret at apex consisting of a central organ with a palp-like organ on each side. *Thorax* (fig. 7) : Only the pronotum sclerotised with median longitudinal suture. Slightly lighter in colour than head. Anterior margin with equally spaced bristles. Transverse furrow near posterior margin extending to pleural region. Posterior margin heavily sclerotised, black in colour. A pattern of dark marks present on the posterior third of the pronotum. Prosternal horn absent. *Legs* : Prothoracic legs (fig. 8) shortest. Metathoracic legs (fig. 10) slightly longer than mesothoracic (fig. 9). Tibia and tarsus of all legs covered with short bristles. All claws long and slender with bristle on inner edge, with a few fine hairs at the point of insertion of the bristles. Ventral edge of femur of all legs furnished with a row of equally spaced bristles. Anterior projection of sclerite supporting coxa of anterior legs triangular and furnished with sense organs. A few branched bristles at the distal extremity of the tarsus of meso- and metathoracic legs. Two black spines on tibia of all legs on distal ventral edge. *Abdomen* (fig. 1) flattened dorsi-ventrally, with fringe of long fine hairs on segments 1—8 in pleural region. Five small processes in middle of posterior margin on dorsal side of ninth segment are eversible gills. Anal appendages (fig. 11) long, each of two segments and a long claw. Distal extremity of second segment oblique with a number of fine hairs on inner margin. Hairs on first segment fine and more numerous. Anal claw obtuse with row of extremely fine spicules on the proximal two-thirds of the inner edge.

Note on Varieties of Larval Coloration.

Many species of Trichoptera show a range of coloration in the larvae due to variation in the intensity of black pigmentation. A single larva collected from South Nutfield, Surrey, in 1946, which was referable to *Plectrocnemia conspersa* showed variation from the normal coloration of quite a distinct type. The meso- and meta-pleura of each side were entirely devoid of pigmentation, being creamy white in colour. The remainder of the larva was of normal pinky-brown coloration. This gave the effect of four distinct pale areas when the larva was viewed from above.

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